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# EXPERIMENTS IN THE DETERMINATION OF THE DIGESTIBILITY OF MILLETS.

By C. F. LANGWORTHY, *Chief*, and A. D. HOLMES, *Scientific Assistant*,
*Office of Home Economics.*

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## INTRODUCTION.

In the study of the digestibility of the nonsaccharine grain sorghums, the results of which were reported in an earlier paper,[1] it was found that the carbohydrates were as completely utilized as those of the more common cereals—wheat, corn, oats, etc.—while the protein of the sorghums was much less available to the human body than that of the better-known cereals. This paper reports the results of a similar study of the digestibility of two millets, common millet (*Setaria italica*) and proso (*Panicum miliaceum*), which are grown in this country and which are of interest because of the possible extension of their use. These grains have been little used for human food in this country, although the latter is receiving considerable attention in some sections. In Russia it is reported[2] that the yearly per capita consumption of proso is 30 pounds; in oriental countries, especially among the poorer people, both of these cereals have been at times extensively employed in the dietary and are staple and well-known grains.

[1] U. S. Dept. Agr. Bul. 470 (1916), Studies on The Digestibilty of the Grain Sorghums.
[2] Inaug. Diss., Imp. Mil. Med. Acad. [St. Petersburg], 1887. [Russian.]

NOTE.—This is a technical report of studies of the digestibility of millet in relation to its use as food and is of special interest to investigators and students of human nutrition.

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A survey of the literature revealed little except empirical information as regards the digestibility and nutritive value of millets. Kurcheninov[1] studied the digestibility of proso, employing five men (physicians and dispensary assistants) of normal health as subjects, for experimental periods of three days each. He prepared the meal, which comprised 63 per cent of the entire grain, by mixing with water and cooking in the form of a thin gruel and a thick mush; the protein of the basal ration, consisting of bouillon, butter, white bread, and cutlets, was found to be 91 per cent utilized, but when the gruel and mush were eaten in conjunction with the basal ration the protein utilization became 43.4 per cent and 43.9 per cent, respectively.

According to Church,[2] the group of cereals which he designates as millets, including common millet and proso, are very important food crops in India. He states that common millet, although it may contain as much as 8 per cent crude fiber in the unhusked grain, is generally considered nutritious and digestible, and that it is prepared by boiling and eaten with or without the addition of sugar, or by parching. Proso is boiled and eaten with sugar and milk, used in curries, or in a form in which the slightly boiled grain is dried, parched in hot sand, sifted from the husks, and eaten with sour milk.

As the millet meals were not found in the open market, a sufficient quantity of millet and proso for the purpose of the investigations was obtained from the Bureau of Plant Industry and ground in the experimental mills at the Bureau of Chemistry. The attempt was made to grind the millets to the same degree of fineness as the sorghum meals used in the experiments referred to, but this was difficult, since the millets have a tough, woody, outer husk, relatively larger in amount than that of the common cereals. When the meal was sifted for bread making (using an ordinary flour sieve of 16 meshes per inch) 40 per cent of millet and 29 per cent of proso (chiefly bran) were removed, quantities much larger than was the case with the other grains previously studied. In other words, the yield of meal of the same degree of fineness as that obtained with the sorghums was smaller.

## PREPARATION OF FOOD.

The millets do not contain gluten and so, used alone, are not suitable for making leavened bread. They can, however, be used for making unleavened bread and, in general, like the grain sorghums, are similar to corn meal in the ways they can be prepared for the table rather than to wheat and rye.

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[1] Inaug. Diss., Imp. Mil. Med. Acad. [St. Petersburg], 1887. [Russian.]

[2] Food-grains of India. London: Chapman and Hall, Limited, 1886, 1901.

It was found that a bread resembling corn cake, but with molasses and a little ginger added to give flavor, was satisfactory for experimental purposes. The ingredients and proportions used in preparing the millet bread were as follows: Fifteen cups of meal, 3¾ teaspoons of salt, 3¾ teaspoons of soda, 5 teaspoons of ginger, 1⅞ cups of molasses, 1 scant cup of shortening (lard), and 2 quarts of hot water. The ingredients were thoroughly mixed and baked for 1½ hours in a moderate oven. The bread prepared according to this method was largely crumb, having only a thin but very hard crust.

The basal ration was so chosen as to contain a minimum amount of protein in order that the larger proportion of this constituent would be derived from the millet. As in earlier tests, it consisted of boiled potato, fruit (orange), and sugar. The subjects were allowed to drink tea or coffee without milk or cream, if they wished, and, of course, all the water desired. The bread was baked each day and accordingly was always served fresh. A quantity of potato sufficient to supply all the subjects for the entire experimental period was boiled and mashed. Sometimes the subjects warmed the potato before eating it and sometimes not.

## ANALYTICAL METHODS.

Samples of the bread were analyzed. The composition of the potato, of the fruit (which furnished a very small proportion of the total protein), and of the sugar was computed from average figures.[1] The feces resulting from the test periods was freed from water by drying at 95° C., then weighed, pulverized, thoroughly mixed, and sampled. The analytical methods followed were those recommended by the Association of Official Agricultural Chemists.[2]

## DETAILS OF THE DIGESTION EXPERIMENTS.

The subjects were urged to eat liberally of the bread and were allowed to eat of the accessory foods served, as they desired. However, the amount of potato served was small, in order that only a relatively small amount of potato protein would be consumed. No attempt was made to have all the subjects eat equal amounts; their preferences varied in some instances quite widely. The food eaten by each was weighed in separate portions, and after each meal any which remained uneaten was also weighed, the difference between these two representing the amount eaten.

Five young men (medical and dental students), who had gained experience in other investigations of like character and had shown themselves trustworthy, served as subjects in this investigation. All were in good health and reasonably active and, so far as could be

[1] U. S. Dept. Agr., Office Expt. Stas. Bul. 28 (1906).
[2] U. S. Dept. Agr., Bur. Chem. Bul. 107 (1907).

judged, had no digestive abnormalities. During the experimental period they were requested to observe their usual routine as regards amount of exercise taken, hours of eating, etc. Because of their interest in the study of physiology and their previous experience in this type of work they were sufficiently informed of the nature of their duties to appreciate the importance of carefully following the directions given them.

For the purpose of identifying the feces of the experimental period, three or four gelatin capsules containing about 0.3 gram each of pulverized charcoal were taken with the first meal of the experimental period and with the first meal following the test period. The separation of the feces due to the diet under investigation was easily made at the line of demarcation between the portion colored by the charcoal and the lighter portion due to the ordinary food.

The subjects were allowed to follow their customary dietary routine before and after the experimental periods. Since this study of millet is concerned with the coefficients of digestibility only, no attempt was made to maintain a nitrogen equilibrium or to maintain uniform body weight of the subjects. The urine resulting from the experimental periods was not collected, for it was considered that any constituents of the food which had been sufficiently broken down to appear in the urine had undergone the process of digestion.

In this study a determination has been made of the digestibility of protein, fat, carbohydrates, and ash of the entire ration, and the digestibility of the protein and carbohydrates of the bread alone has been estimated by a method commonly employed in investigations of this character, which consists of making proper allowance for the amount of undigested residue occurring from the various constituents of the diet other than bread. The following equations will serve to indicate the method by which this allowance has been made:

[Weight of protein in potato, butter, and fruit] $\times$ [Per cent of undigested protein occurring in each] = [Weight of undigested protein present in feces derived from basal ration].

[Total undigested protein in feces] — [Undigested protein in feces from basal ration] = [Undigested protein occurring from bread].

[(Total protein of bread) — (Undigested protein from bread)] $\div$ [Total protein of bread] = [Estimated percentage digestibility of protein in bread alone].

The factors used in the above equations for estimating the coefficients of digestibility of the protein and carbohydrates of bread alone have been determined in previous investigations as being for the protein of potatoes, 83 per cent;[1] of butter, 97 per cent;[1] and of fruit, 85 per cent;[1] while the digestibility of carbohydrates in

[1] Connecticut Storrs Sta. Rpt. 1899, p. 104.

potatoes and fruit has been found to be 95 per cent[1] and 90 per cent,[1] respectively.

The details of the digestion experiments are recorded in the following tables, which include the kind, amount, and total weight of different foods eaten by each subject, the weight of the various constituents of the foods, the weight of the feces, the amount of food utilized, the coefficients of digestibility of the entire ration, and the estimated digestibility of the bread alone.

*Data of digestion experiments with millet in a simple mixed diet.*

| | Weight. | Water. | Protein. | Fat. | Carbohydrates. | Ash. |
|---|---|---|---|---|---|---|
| Experiment No. 425, subject D. G. G.: | *Grams.* | *Grams.* | *Grams.* | *Grams.* | *Grams.* | *Grams.* |
| Bread | 1,299.0 | 324.7 | 130.7 | 98.9 | 688.7 | 56.0 |
| Potato | 624.0 | 471.1 | 15.6 | .6 | 130.4 | 6.3 |
| Fruit | 964.0 | 859.9 | 2.9 | 3.9 | 95.4 | 1.9 |
| Butter | 413.0 | 45.4 | 4.1 | 351.1 | ..... | 12.4 |
| Sugar | 72.0 | ..... | ..... | ..... | 72.0 | ..... |
| Total food consumed | 3,372.0 | 1,701.1 | 153.3 | 454.5 | 986.5 | 76.6 |
| Feces | 199.0 | ..... | 104.4 | 15.1 | 58.9 | 20.6 |
| Amount utilized | ..... | ..... | 48.9 | 439.4 | 927.6 | 56.0 |
| Digestibility of entire ration (per cent) | ..... | ..... | 31.9 | 96.7 | 94.0 | 73.1 |
| Estimated digestibility of bread alone (per cent) | ..... | ..... | 22.6 | ..... | 94.0 | ..... |
| Experiment No. 426, subject A. J. H.: | | | | | | |
| Bread | 1,244.0 | 311.0 | 125.1 | 94.7 | 659.6 | 53.6 |
| Potato | 647.0 | 488.5 | 16.2 | .6 | 135.2 | 6.5 |
| Fruit | 792.0 | 706.4 | 2.4 | 3.2 | 78.4 | 1.6 |
| Butter | 364.0 | 40.1 | 3.6 | 309.4 | ..... | 10.9 |
| Sugar | 82.0 | ..... | ..... | ..... | 82.0 | ..... |
| Total food consumed | 3,129.0 | 1,546.0 | 147.3 | 407.9 | 955.2 | 72.6 |
| Feces | 173.0 | ..... | 90.8 | 19.8 | 44.9 | 17.5 |
| Amount utilized | ..... | ..... | 56.5 | 388.1 | 910.3 | 55.1 |
| Digestibility of entire ration (per cent) | ..... | ..... | 38.4 | 95.1 | 95.3 | 75.9 |
| Estimated digestibility of bread alone (per cent) | ..... | ..... | 30.0 | ..... | 95.6 | ..... |
| Experiment No. 427, subject R. L. S.: | | | | | | |
| Bread | 1,102.0 | 275.5 | 110.8 | 83.9 | 584.3 | 47.5 |
| Potato | 215.0 | 162.3 | 5.4 | .2 | 44.9 | 2.2 |
| Fruit | 892.0 | 795.6 | 2.7 | 3.6 | 88.3 | 1.8 |
| Butter | 197.0 | 21.7 | 2.0 | 167.4 | ..... | 5.9 |
| Sugar | 87.0 | ..... | ..... | ..... | 87.0 | ..... |
| Total food consumed | 2,493.0 | 1,255.1 | 120.9 | 255.1 | 804.5 | 57.4 |
| Feces | 156.0 | ..... | 79.1 | 18.2 | 40.4 | 18.3 |
| Amount utilized | ..... | ..... | 41.8 | 236.9 | 764.1 | 39.1 |
| Digestibility of entire ration (per cent) | ..... | ..... | 34.6 | 92.9 | 95.0 | 68.1 |
| Estimated digestibility of bread alone (per cent) | ..... | ..... | 29.9 | ..... | 95.3 | ..... |
| Experiment No. 448, subject D. G. G.: | | | | | | |
| Bread | 1,397.0 | 366.2 | 138.9 | 113.4 | 722.9 | 55.6 |
| Potato | 549.0 | 414.5 | 13.7 | .6 | 114.7 | 5.5 |
| Fruit | 652.0 | 571.8 | 2.0 | 2.6 | 74.3 | 1.3 |
| Butter | 344.0 | 37.8 | 3.5 | 292.4 | ..... | 10.3 |
| Sugar | 162.0 | ..... | ..... | ..... | 162.0 | ..... |
| Total food consumed | 3,104.0 | 1,390.3 | 158.1 | 409.0 | 1,073.9 | 72.7 |
| Feces | 191.0 | ..... | 92.7 | 21.2 | 57.4 | 19.7 |
| Amount utilized | ..... | ..... | 65.4 | 387.8 | 1,016.5 | 53.0 |
| Digestibility of entire ration (per cent) | ..... | ..... | 41.4 | 94.8 | 94.7 | 72.9 |
| Estimated digestibility of bread alone (per cent) | ..... | ..... | 35.2 | ..... | 94.3 | ..... |

[1] Connecticut Storrs Sta. Rpt. 1899, p. 104.

*Data of digestion experiments with millet in a simple mixed diet*—Continued.

| | Weight. | Water. | Protein. | Fat. | Carbohydrates. | Ash. |
|---|---|---|---|---|---|---|
| Experiment No. 449, subject A. J. H.: | *Grams.* | *Grams.* | *Grams.* | *Grams.* | *Grams.* | *Grams.* |
| Bread | 1,239.0 | 324.7 | 123.2 | 100.6 | 641.2 | 49.3 |
| Potato | 539.0 | 406.9 | 13.5 | .5 | 112.7 | 5.4 |
| Fruit | 759.0 | 665.7 | 2.3 | 3.0 | 86.5 | 1.5 |
| Butter | 311.0 | 34.2 | 3.1 | 264.4 | ..... | 9.3 |
| Sugar | 131.0 | ..... | ..... | ..... | 131.0 | ..... |
| Total food consumed | 2,979.0 | 1,431.5 | 142.1 | 368.5 | 971.4 | 65.5 |
| Feces | 176.0 | ..... | 92.0 | 26.4 | 37.9 | 19.7 |
| Amount utilized | ..... | ..... | 50.1 | 342.1 | 933.5 | 45.8 |
| Digestibility of entire ration (per cent) | ..... | ..... | 35.3 | 92.8 | 96.1 | 69.9 |
| Estimated digestibility of bread alone (per cent) | ..... | ..... | 27.5 | ..... | 96.7 | ..... |
| Experiment No. 450, subject R. L. S.: | | | | | | |
| Bread | 1,549.0 | 406.0 | 154.0 | 125.8 | 801.6 | 61.6 |
| Potato | 505.0 | 381.3 | 12.6 | .5 | 105.5 | 5.1 |
| Fruit | 674.0 | 591.1 | 2.0 | 2.7 | 76.8 | 1.4 |
| Butter | 281.0 | 30.9 | 2.8 | 238.9 | ..... | 8.4 |
| Sugar | 77.0 | ..... | ..... | ..... | 77.0 | ..... |
| Total food consumed | 3,086.0 | 1,409.3 | 171.4 | 367.9 | 1,060.9 | 76.5 |
| Feces | 140.0 | ..... | 63.4 | 19.3 | 39.1 | 18.2 |
| Amount utilized | ..... | ..... | 108.0 | 348.6 | 1,021.8 | 58.3 |
| Digestibility of entire ration (per cent) | ..... | ..... | 63.0 | 94.8 | 96.3 | 76.2 |
| Estimated digestibility of bread alone (per cent) | ..... | ..... | 60.5 | ..... | 96.9 | ..... |
| Experiment No. 451, subject O. E. S.: | | | | | | |
| Bread | 1,073.0 | 281.2 | 106.7 | 87.1 | 555.3 | 42.7 |
| Potato | 691.0 | 521.7 | 17.3 | .7 | 144.4 | 6.9 |
| Fruit | 653.0 | 572.7 | 2.0 | 2.6 | 74.4 | 1.3 |
| Butter | 263.0 | 28.9 | 2.6 | 223.6 | ..... | 7.9 |
| Sugar | 165.0 | ..... | ..... | ..... | 165.0 | ..... |
| Total food consumed | 2,845.0 | 1,404.5 | 128.6 | 314.0 | 939.1 | 58.8 |
| Feces | 128.0 | ..... | 62.4 | 18.0 | 33.3 | 14.3 |
| Amount utilized | ..... | ..... | 66.2 | 296.0 | 905.8 | 44.5 |
| Digestibility of entire ration (per cent) | ..... | ..... | 51.5 | 94.3 | 96.5 | 75.7 |
| Estimated digestibility of bread alone (per cent) | ..... | ..... | 44.6 | ..... | 97.2 | ..... |
| Average food consumed per subject per day | 1,000.4 | 482.7 | 48.7 | 122.7 | 323.4 | 22.9 |

*Summary.*

| Experiment No. | Subject. | Digestibility of entire ration. | | | | Estimated digestibility of protein of bread alone. | Estimated digestibility of carbohydrates of bread alone. |
|---|---|---|---|---|---|---|---|
| | | Protein. | Fat. | Carbohydrates. | Ash. | | |
| | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| 425 | D. G. G. | 31.9 | 96.7 | 94.0 | 73.1 | 22.6 | 94.0 |
| 426 | A. J. H. | 38.4 | 95.1 | 95.3 | 75,9 | 30.0 | 95.6 |
| 427 | R. L. S. | 34.6 | 92.9 | 95.0 | 68.1 | 29.9 | 95.3 |
| 448 | D. G. G. | 41.4 | 94.8 | 94.7 | 72.9 | 35.2 | 94.3 |
| 449 | A. J. H. | 35.3 | 92.8 | 96.1 | 69.9 | 27.5 | 96.7 |
| 450 | R. L. S. | 63.0 | 94.8 | 96.3 | 76.2 | 60.5 | 96.9 |
| 451 | O. E. S. | 51.5 | 94.3 | 96.5 | 75.7 | 44.6 | 97.2 |
| | Average | 42.3 | 94.4 | 95.4 | 73.1 | 35.8 | 95.7 |

*Data of digestion experiments with proso in a simple mixed diet.*

| | Weight. | Water. | Protein. | Fat. | Carbohydrates. | Ash. |
|---|---|---|---|---|---|---|
| Experiment No. 468, subject D. G. G.: | *Grams.* | *Grams.* | *Grams.* | *Grams.* | *Grams.* | *Grams.* |
| Bread | 1,268.0 | 441.9 | 111.0 | 76.3 | 602.0 | 36.8 |
| Potato | 591.0 | 446.2 | 14.8 | .6 | 123.5 | 5.9 |
| Fruit | 1,075.0 | 934.2 | 8.6 | 2.1 | 124.7 | 5.4 |
| Butter | 430.0 | 47.3 | 4.3 | 365.5 | ..... | 12.9 |
| Sugar | 116.0 | ..... | ..... | ..... | 116.0 | ..... |
| Total food consumed | 3,480.0 | 1,869.6 | 138.7 | 444.5 | 966.2 | 61.0 |
| Feces | 153.0 | ..... | 78.4 | 16.7 | 43.9 | 14.0 |
| Amount utilized | ..... | ..... | 60.3 | 427.8 | 922.3 | 47.0 |
| Digestibility of entire ration (per cent) | ..... | ..... | 43.5 | 96.2 | 95.5 | 77.0 |
| Estimated digestibility of bread alone (per cent) | ..... | ..... | 32.9 | ..... | 96.2 | ..... |
| Experiment No. 469, subject H. R. G.: | | | | | | |
| Bread | 1,196.0 | 416.8 | 104.6 | 72.0 | 567.9 | 34.7 |
| Potato | 585.0 | 441.7 | 14.6 | .6 | 122.3 | 5.8 |
| Fruit | 993.0 | 862.9 | 7.9 | 2.0 | 115.2 | 5.0 |
| Butter | 323.0 | 35.5 | 3.2 | 274.6 | ..... | 9.7 |
| Sugar | ..... | ..... | ..... | ..... | ..... | ..... |
| Total food consumed | 3,097.0 | 1,756.9 | 130.3 | 349.2 | 805.4 | 55.2 |
| Feces | 157.0 | ..... | 76.3 | 15.8 | 52.5 | 12.4 |
| Amount utilized | ..... | ..... | 54.0 | 333.4 | 752.9 | 42.8 |
| Digestibility of entire ration (per cent) | ..... | ..... | 41.4 | 95.5 | 93.5 | 77.5 |
| Estimated digestibility of bread alone (per cent) | ..... | ..... | 30.7 | ..... | 93.9 | ..... |
| Experiment No. 470, subject A. J. H: | | | | | | |
| Bread | 980.0 | 341.5 | 85.8 | 59.0 | 465.3 | 28.4 |
| Potato | 535.0 | 403.9 | 13.4 | .5 | 111.8 | 5.4 |
| Fruit | 1,016.0 | 882.9 | 8.1 | 2.0 | 117.9 | 5.1 |
| Butter | 469.0 | 51.6 | 4.7 | 398.6 | ..... | 14.1 |
| Sugar | 116.0 | ..... | ..... | ..... | 116.0 | ..... |
| Total food consumed | 3,116.0 | 1,679.9 | 112.0 | 460.1 | 811.0 | 53.0 |
| Feces | 132.0 | ..... | 57.3 | 32.4 | 28.2 | 14.1 |
| Amount utilized | ..... | ..... | 54.7 | 427.7 | 782.8 | 38.9 |
| Digestibility of entire ration (per cent) | ..... | ..... | 48.8 | 93.0 | 96.5 | 73.4 |
| Estimated digestibility of bread alone (per cent) | ..... | ..... | 37.4 | ..... | 98.2 | ..... |
| Experiment No. 471, subject P. K.: | | | | | | |
| Bread | 1,539.0 | 536.3 | 134.6 | 92.7 | 730.7 | 44.6 |
| Potato | 539.0 | 406.9 | 13.5 | .5 | 112.7 | 5.4 |
| Fruit | 824.0 | 716.1 | 6.6 | 1.7 | 95.6 | 4.1 |
| Butter | 392.0 | 43.1 | 3.9 | 333.2 | ..... | 11.8 |
| Sugar | 15.0 | ..... | ..... | ..... | 15.0 | ..... |
| Total food consumed | 3,309.0 | 1,702.4 | 158.6 | 428.1 | 954.0 | 65.9 |
| Feces | 119.0 | ..... | 52.0 | 14.6 | 40.2 | 12.2 |
| Amount utilized | ..... | ..... | 106.6 | 413.5 | 913.8 | 53.7 |
| Digestibility of entire ration (per cent) | ..... | ..... | 67.2 | 96.6 | 95.8 | 81.5 |
| Estimated digestibility of bread alone (per cent) | ..... | ..... | 63.9 | ..... | 96.6 | ..... |
| Average food consumed per subject per day | 1,083.5 | 584.0 | 45.0 | 140.2 | 294.7 | 19.6 |

*Summary.*

| Experiment No. | Subject. | Digestibility of entire ration. | | | | Estimated digestibility of protein of bread alone. | Estimated digestibility of carbohydrates of bread alone. |
|---|---|---|---|---|---|---|---|
| | | Protein. | Fat. | Carbohydrates. | Ash. | | |
| | | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| 468 | D. G. G. | 43.5 | 96.2 | 95.5 | 77.0 | 32.9 | 96.2 |
| 469 | H. R. G. | 41.4 | 95.5 | 93.5 | 77.5 | 30.7 | 93.9 |
| 470 | A. J. H. | 48.8 | 93.0 | 96.5 | 73.4 | 37.4 | 98.2 |
| 471 | P. K. | 67.2 | 96.6 | 95.8 | 81.5 | 63.9 | 96.6 |
| | Average. | 50.2 | 95.3 | 95.3 | 77.4 | 41.2 | 96.2 |

The total amount of food eaten on the average per subject per day was for the experiments with common millet, 1,000 grams, and with proso, 1,084 grams, which furnished 49 grams of protein, 123 grams of fat, 323 grams of carbohydrates in the millet experiments, and 45 grams of protein, 140 grams of fat, and 295 grams of carbohydrates in the proso experiments. Inasmuch as the subjects ate of the ration according to individual inclination, the heat of combustion varied quite materially—from a maximum of 3,080 calories to a minimum of 2,140 calories per day, as computed by the factors commonly used in the determination of fuel values of foods.

Notwithstanding the quantity eaten, the amount of protein supplied by the ration was low, being on an average less than 50 grams per day, due to the low protein content of the bread prepared from these grains and to its bulky nature.

The values reported for the digestibility of fat of the entire ration more truly represent the digestibility of butter than of the cereal fats, since the latter were present in such relatively small quantities. The values, 94.4 per cent and 95.3 per cent, for the millet and proso rations, respectively, agree with the values for the digestibility of butter reported in connection with a study of the digestibility of hard palates of cattle and in a study of the digestibility of butter, which were 94.6 per cent[1] and 97 per cent,[2] respectively.

The breads made from bolted millet and proso meal do not show a high digestibility for protein in these experiments, the values being 35.8 per cent for millet protein and 41.2 per cent for proso protein. There was no marked difference in the flavor of the millet and proso breads. In India, where they are regarded as important foodstuffs, these grains are commonly boiled, and it is possible that thus prepared they might be more thoroughly digested.

[1] U. S. Dept. Agr., Jour. Agr. Research, 6 (1916), No. 17, p. 647.
[2] U. S. Dept. Agr. Bul. 310 (1915), p. 21.

A small quantity of decorticated millet was tested as to culinary quality, and when boiled the mush was found to be of pleasing flavor. The available quantity was not sufficient for a study of its digestibility.

In discussing the results of experiments with man too much weight should not be given to those obtained with ruminants, but it is not without interest to note that the millet proteins are not as well utilized by the animal body as the proteins of the more common cereals, as indicated by the experiment of Shepard and Koch.[1] Sheep were fed unground grains in connection with a roughage, and it was found that of two varieties of millets the protein was 70 per cent and 55 per cent utilized, while in the case of oats 77 per cent and of corn 78 per cent was utilized by the same sheep under like experimental conditions.

As regards the carbohydrates of millet and proso, it was found in the experiments here reported that this constituent was as well utilized by the subjects as in the case of the more common cereals, the coefficients of digestibility being 95.7 per cent for millet and 96.2 per cent for proso.

In general, therefore, it seems fair to conclude from the data reported that while the millets would contribute somewhat to the protein of the diet, they would be decidedly more important as a source of carbohydrates than of protein. In this they resemble such grains as the sorghums more closely than they do wheat or rye, which are important sources of both protein and carbohydrates.

[1] South Dakota Sta. Bul. 114 (1909), p. 553. Digestion coefficients of grains and fodders for South Dakota.

## PUBLICATIONS OF THE U. S. DEPARTMENT OF AGRICULTURE RELATING TO STUDIES OF FOODS.

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